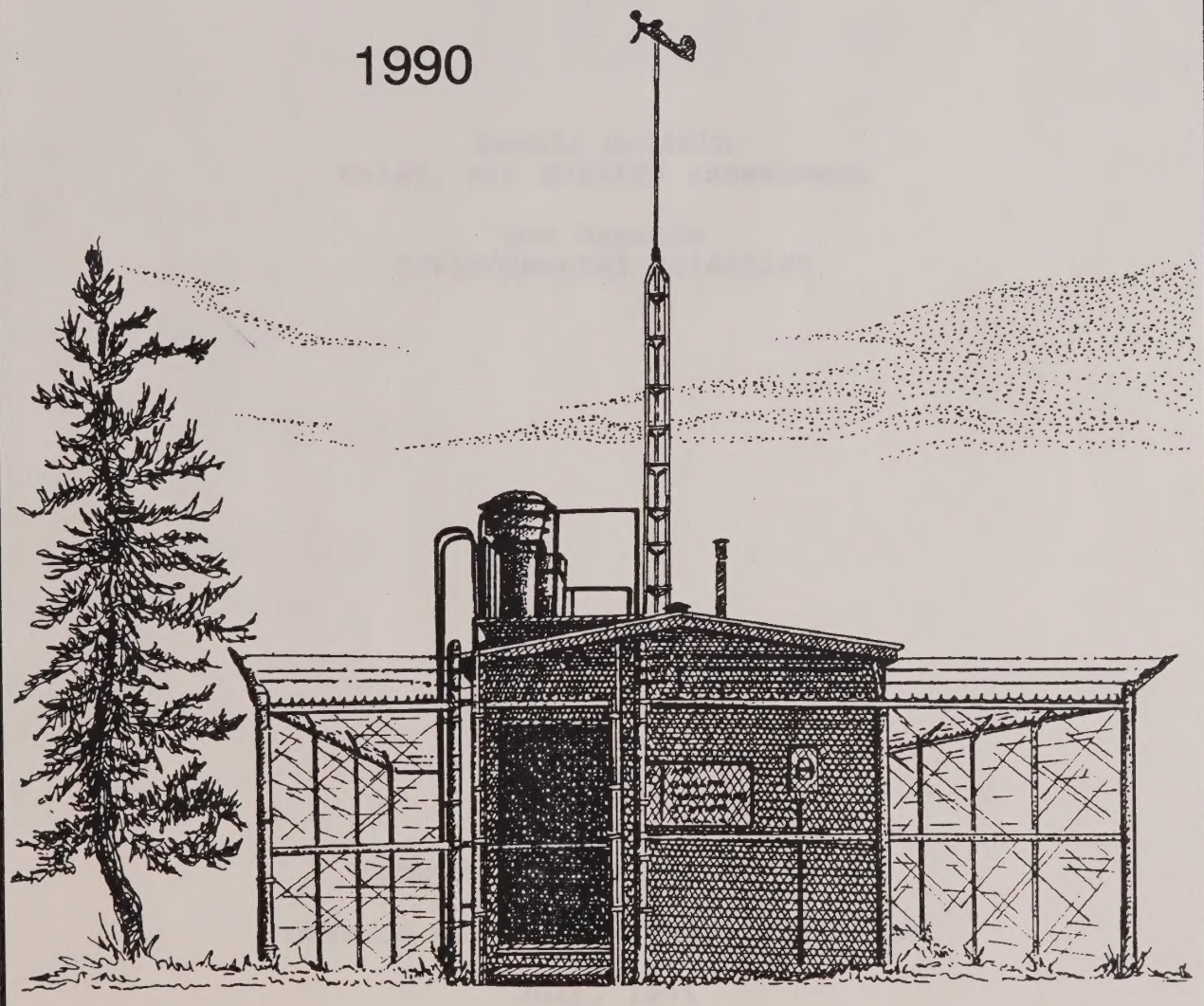
AIR QUALITY

NORTHWESTERN ONTARIO

1990



ISSN 0713-9330

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NORTHWESTERN ONTARIO

1990

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ONTARIO MINISTRY OF THE ENVIRONMENT

July, 1991

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SUMMARY

This technical memorandum presents results of the Ministry's air quality assessment program for 1990 in northwestern Ontario. It includes data from 11 communities where long-term monitoring is conducted.

ATIKOKAN

During 1990, there were no exceedences of air quality objectives for sulphur dioxide, nitrogen dioxide or ozone near Ontario Hydro's lignite-fueled power plant at Atikokan. Negligible environmental impact was found from particulate fallout near coal storage and ash disposal sites near the plant.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. Arsenic levels increased at some sampling sites in 1990, compared to 1989. Interim results of a special survey showed that airborne arsenic on and off Dickenson Mines property met air quality objectives.

During the growing season (May to September), hourly average sulphur dioxide exceeded the acceptable limit 34 times, the same as in 1989. There were two small areas of visible vegetation injury caused by sulphur dioxide on the Campbell Mine property, but not in the townsite. The principal sulphur dioxide source is the ore concentrate roaster at the Campbell Mine. By mid-1991, the roaster will be shut down and emissions of sulphur dioxide (and arsenic) from ore roasting will cease.

DRYDEN

Odour levels in central Dryden continued the excellent record of recent years. The Ontario guideline for total reduced sulphur (TRS) was exceeded only three times in 1990.

FORT FRANCES

There was no visible off-property vegetation damage caused by air emissions from the local kraft pulp mill. Foliar sodium levels were below the contaminant guideline at all sampling sites around the mill, indicating good control of particulate emissions from the mill's recovery furnace.

Average dustfall continued to exceed Ministry objectives off mill property, but levels continued to show an encouraging decline. Improved emission controls on the mill's recovery boiler are credited for ongoing improvement. Wood fines still sometimes contribute significantly to elevated dustfall. Average suspended particulate concentrations were acceptable.

Odour levels increased from 1989 to 1990 at the Ministry's main monitoring site in Fort Frances. TRS guideline exceedences at this site rose from 414 in 1989, to 493 in 1990. At the Air Quality Index station, there were 850 hours of moderate air quality and 511 hours of poor air quality. Odour controls being introduced into the Fort Frances pulp mill in 1991 should improve community air quality.

KENORA

Substantial compliance with the Ontario dustfall objective was achieved in Kenora in 1990. Upgraded pollution controls on the power boiler system at the local sulphite pulp mill are credited with this achievement. Average Kenora dustfall has shown a clear trend of improvement over the past 17 years.

MARATHON

There was general compliance with dustfall objectives near a wood-chip storage area at a local kraft pulp mill.

Odour levels near the mill improved during the year, compared with preceding years; there were only 21 exceedences of the TRS guideline in 1990 compared with 54 in 1989 and 109 in 1988.

An air emission inventory carried out by the mill in 1989 showed some emission sources were not in compliance with Ministry regulations. This issue will be addressed through a Control Order or through mill modernization plans.

RED LAKE

Following two exceedences of the 24-hour air quality objective for lead in 1988, lead levels have since been satisfactory near a mineral assay laboratory in Red Lake. Emission controls were installed in 1989. Routine air sampling was discontinued at the end of 1990.

RED ROCK

More than 90% of dustfall measurements complied with Ministry objectives near a kraft pulp mill in Red Rock. There has been a clear trend of dustfall decline in the past 12 years.

Air quality with respect to odours declined in 1990 compared with 1989: The provincial TRS guideline was exceeded 80 times in 1990, up from 44 in 1989. Odour controls recently completed or in progress should improve air quality in 1991.

SCHREIBER

The latest surveys have shown evidence of some slippage in a dust control program to minimize emissions from a base metal ore concentrate transfer site on CPR property in Schreiber. CP Rail will be tightening up its operation to address this problem.

TERRACE BAY

Air quality in Terrace Bay in 1990 improved from 1989, and was the best recorded during the past 5 years. Data from the two monitoring stations indicated that the spills collection pond at the local kraft pulp mill was the main source of TRS impacting community air quality. The mill's secondary wastewater treatment system appears to be an insignificant odour source.

THUNDER BAY

Particulate emissions from a local pulp mill caused some exceedances of dustfall objectives at two monitoring sites. Because of consistently low readings, the rest of the dustfall network was closed down at the end of 1989.

Suspended particulate matter met the annual provincial objective at all sites monitored; the network was reduced from six sites to four at the end of the year. Soiling index levels were also acceptable at all times during the year.

Concentrations of carbon monoxide, nitrogen dioxide, ozone and sulphur dioxide consistently met Ministry objectives in 1990. The TRS guideline near a kraft pulp mill was exceeded 16 times. During the year, Thunder Bay's Air Quality Index was "very good" or "good" for all but 17 hours, when it was "moderate" due to suspended particles (16 hours) or TRS (1 hour).

Airborne dust levels were satisfactory in residential areas near Thunder Bay Terminals Limited. A dust control program implemented by the company reduced the off-property spread of coal dust on the Lake Superior side of the facility.

INTRODUCTION

1.0 PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts air quality assessment programs throughout the province. Monitoring networks record outdoor concentrations of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys document compliance with air quality objectives, and determine long-term air quality trends. The monitoring program identifies pollution sources and assesses the results of pollution control measures.

In northwestern Ontario, air quality surveys first began in 1963, to measure airborne dust in the City of Thunder Bay. In 1990, the regional monitoring network covered 11 communities, with nearly 80 monitoring devices. More than 20 different pollutants were measured, plus meteorological parameters. Ontario Hydro also operated air quality networks in Thunder Bay and Atikokan.

Data from air quality and meteorological instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mines, pulp and paper mills). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and in parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout throughout the province. The Ministry's Northwestern Region currently participates in this program through precipitation sampling surveys (nine sites in 1990) and through lake sampling surveys. The findings of these studies are reported elsewhere.

The installation of a telemetry system in 1986 was a major new enhancement of the region's air quality monitoring program. This system greatly increased the speed with which air quality data are received. It permits the Ministry to obtain immediate readings from any continuous monitor. Beginning in early June, 1988, an Air Quality Index (AQI) has been issued eight times daily for Thunder Bay and other cities in Ontario. The Thunder Bay AQI is based on readings for six pollutants: carbon monoxide, ozone, nitrogen dioxide, suspended particles (soiling index), sulphur dioxide, and total reduced sulphur. In September 1989, an AQI station was added in Fort Frances to publish levels of total reduced sulphur. Other communities may be added in future.

2.0 POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario are considered. If the need arises, some of the more unusual pollutants (mainly organic compounds) can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

2.1 Particulate Matter

There are many man-made and natural sources of airborne particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may harm health and vegetation, may affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), inhalable particulate matter (IPM), and soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed.[1] The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days). The annual objective is 4.6 $g/m^2/30$ d. Dustfall estimates the fallout of particulate matter from local sources, including dust from construction or from vehicles. It is rarely considered to be a health-related pollutant, but may cause a significant nuisance because of soiling effects.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day.[2] The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected.

The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic meter of air sampled) averaged over 24 hours, and 60 $\mu g/m^3$, annual geometric mean.

Inhalable particulate matter comprises particles smaller than 10 μm (micrometres) in diameter. It is measured with a standard high-volume sampler fitted with a size-selective inlet. Samples are collected on a quartz filter exposed for a 24-hour period every sixth day. An Ontario air quality objective for inhalable particulate matter is being developed.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light

transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

2.2 Gaseous Pollutants

2.2.1 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. Its primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion. As the number of vehicles in northwestern Ontario is small relative to other parts of the province, carbon monoxide is not a problem pollutant in this region. Elevated concentrations of carbon monoxide cause well-known health effects. The maximum acceptable level in Ontario is 30 ppm (parts of carbon monoxide per million parts of air), 1-hour average, and 13 ppm, 8-hour average. This pollutant is measured with a continuous analyzer[3] at one location in Thunder Bay.

2.2.2 Nitrogen Oxides (NO_x)

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both NO and NO_2 may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may adversely affect health and visibility. NO_2 also reacts with hydrocarbons in sunlight to form ozone. It may also combine with water to form nitric acid, a component of acid rain. In Northwestern Ontario, Nitrogen oxides are monitored with a continuous analyzer[4] at one location in Thunder Bay. The air quality objectives for NO_2 in Ontario are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

2.2.3 Ozone (O_3)

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a product of reactions between nitrogen oxides and hydrocarbons. If present at high concentrations, it may affect health and vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. Ozone is measured with continuous analyzers[5] at two sites in the region. The current air quality objective is 0.08 ppm, averaged over one hour.

2.2.4 Sulphur Dioxide (SO_2)

Sulphur dioxide is one of the world's major atmospheric pollutants and has many well-known effects on health, vegetation and property. It is also one of the main contributors to acid rain. In northwestern Ontario, the principal SO_2 sources are small compared to those in some other parts of the province. The main regional emitters of SO_2 are, in approximate descending order of importance, Ontario Hydro generating stations (Thunder Bay and Atikokan), sulphite pulp mills, gold ore roasting, and industrial boilers. The Ministry measures sulphur dioxide with continuous analyzers[6] at two locations in the region. There are three air quality objectives for this pollutant: 0.25 ppm, hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

2.2.5 Total Reduced Sulphur (TRS)

Total reduced sulphur comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS sources in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary

discomfort to sensitive individuals. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS is measured with continuous analyzers[7] at 11 sites in northwestern Ontario.

2.2.6 Organic Compounds

The Ministry is expanding its small network for measuring organic compounds. The compound groups included in this network are dioxins/furans, VOCs (volatile organic compounds) and PAHs (polynuclear aromatic hydrocarbons). These pollutants are often called "air toxics", and are of special interest as possible health risks in urban areas. The VOC group in the Ministry's air monitoring program currently includes 35 compounds. There are 33 PAH compounds analyzed.

In northwestern Ontario, there is one VOC and one PAH monitor in Thunder Bay. A dioxin/furan sampler was operated in Marathon for a year in 1990. Expansion of organics measurement to the region will occur as resources permit.

2.3 Miscellaneous

The occurrence and effects of some of the foregoing pollutants, plus others, may be assessed by vegetation injury and by determining contaminant levels in vegetation, soil and snow. Standard Ministry procedures,[8,9,10] are followed in collecting and analyzing these types of samples. Arsenic, chloride, fluoride,[11] sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background values at sites unaffected by pollution. Contaminant guidelines developed by the Ministry for vegetation, soil and snow are used in this report. The guidelines are based on the upper limit of

"normal" elemental concentrations across the province. Exceedence of a guideline may indicate a contamination problem. However, it is not a violation of Ministry regulations, nor does it necessarily imply health or environmental effects.

Most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. The Ministry's Toronto laboratory analyses inhalable particulate matter, plus sulphur and halides (chloride, fluoride) in vegetation and soil. The Toronto laboratory also analyses VOC (volatile organic compounds) and PAH (polynuclear aromatic hydrocarbons). A private laboratory carries out dustfall and suspended particulate matter determinations.

The Ministry's Air Resources Branch produces computer printouts of all air quality and meteorological data for the region.

RESULTS

3.0 ATIKOKAN

3.1 Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began air quality studies around a lignite-fired generating station under construction near Atikokan. Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples at several sites (Figure 1).

By late 1985, when the 200-megawatt plant went into service, at least three years of background data had been collected. A summary report for the pre-operational terrestrial and atmospheric deposition studies was issued in 1986.[12]

The Ministry and Ontario Hydro continued their monitoring programs during 1986, 1987 and 1988, which were the first three operating years for the power plant. Ontario Hydro's environmental quality compliance reports show that there were no exceedences of Ontario's air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide during this period, or more recently. Reports on atmospheric deposition and terrestrial data for the same period revealed no significant changes from the pre-operational period.[13,14] The terrestrial studies concluded in 1988; re-sampling is scheduled for 1992. In 1990, deposition monitoring was discontinued at Lac La Croix. Quetico Centre (Eva Lake) continued as a cumulative sampling site, but daily measurements at this location terminated. Monitoring at Fernberg Road (northern Minnesota) will continued without change. A new monitoring site, near the shore of Lake Superior in northern Minnesota, was established in late 1990. This site will record deposition of air toxics (metals, pesticides, persistent organics) as part of a study covering the Great Lakes.

In 1990, a report was released on air quality studies near coal storage and ash disposal areas near the Atikokan generating station.[15] The report showed that these areas were minor sources of fallout of particulate matter. No environmental impact was expected.

4.0 BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, the Campbell Mine (Placer Dome Inc.) and the Arthur W. White Mine (Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson shut down its roaster.

4.1 Arsenic

In 1990, arsenic concentrations in leaves of trembling aspen trees at 17 sites near the mines (Figure 2) remained elevated on mine properties but were near normal in the townsite. Elevated arsenic near the mines is ascribed to localized fugitive emissions from arsenic-containing wastes or from concentrates. Stack emissions may also contribute to arsenic fallout. Table 1 compares arsenic readings for the past 5 years at selected sites on and off mine properties. After declining the past few years, average arsenic increased in 1990. Most of this increase was caused by a high arsenic concentration at site 13, on Dickenson Mines property. Dust from construction on Campbell's property may have been the reason for an increase at some of the other sites.

Table 2 presents arsenic data for 1986-90 from planted roadside trees in the townsite. Tables 1 and 2 both show that current arsenic levels in tree vegetation in the townsite are above normal.

Because residential gardens regularly sampled in Balmertown are no longer in use, garden vegetables have not been sampled since 1988. In recent years, arsenic levels in vegetables have been acceptable. Because arsenic in garden soil remains high, Balmertown residents have been advised to thoroughly wash vegetables from their gardens.

Interim results of a special survey on and off the property of Dickenson Mines Limited revealed compliance with air quality objectives for arsenic and heavy metals.[16]

4.2 Sulphur Dioxide

Sulphur dioxide sometimes exceeds desirable levels in Balmertown. In 1990, the Ministry's Balmertown monitor recorded 63 hourly SO2 readings and five, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.65 ppm, more than double the Ontario objective. The annual average (0.007 ppm) was satisfactory. In 1990, there were two small areas, totalling about 2.4 hectares, of visible sulphur dioxide injury to vegetation on the Campbell mine property.

During the growing season (May to September), SO2 was above the acceptable hourly limit 34 times, the same as in 1990. Table 3 summarizes the data for the past 5 years. When operationally feasible during the growing season, Campbell shuts down its ore roaster when the wind carries roaster-stack emissions over the townsite. Generally, this program has succeeded in minimizing vegetation damage off mine property. The company, at a cost of nearly $25 million, is changing its ore processing operation to eliminate roasting. This change, scheduled to be on line by July, 1991, will eliminate airborne emissions of SO_2 as well as arsenic.

5.0 DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill in Dryden. Abatement action, process changes, and mill modernization have resolved most of the air quality concerns of the 1970's and early 1980's. Currently, the Ministry monitors odour levels in the town centre.

5.1 Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with a continuous TRS analyzer in central Dryden (station 61027, Figure 3). As Table 4 shows, odour levels in 1990 were generally satisfactory throughout the year. There were only three exceedences of the provincial guideline for TRS. These occurrences were caused by temporary operating upsets at the mill.

6.0 FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in particulate fallout and odour problems in a nearby residential area. In the late 1970's, some emission reductions were achieved. In 1980, a Control Order was issued for further pollution controls. The mill also created a "buffer zone" through purchase of adjacent residential land.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and periodically since 1974 around a similar nearby plant owned by the parent corporation on the U.S. side of the border (Figure 4).

6.1 Vegetation Effects

In 1990, there was no visible air pollution injury to vegetation inside or outside the buffer zone around the Fort Frances mill. The condition of trees which had suffered damage in past years was mostly unchanged from 1989. Sodium in tree foliage was very low in 1990 samples. Table 5 compares the past 4 years of data with sodium levels in 1980, selected as typical for average conditions from 1975 to 1986. Sodium in the past few years has clearly been well below the average of the preceding decade. Figure 5 presents the data graphically. The decline in sodium is evidence of reduced fallout of saltcake from the Fort Frances mill.

There was no visible off-property damage to vegetation around the pulp mill's secondary effluent treatment system on Eighth Street (Figure 6).

6.2 Particulate Matter

Dustfall results for 1990 are summarized in Table 6. The annual air quality objective for dustfall was met at the three most distant monitoring sites from the Fort Frances mill (stations 62032, 62034 and 62037). Dustfall on mill property averaged more than twice the objective. Dustfall in the nearby residential area (excluding the two most distant sites) averaged 25% above the objective. Wood fibres accounted for about 25 to 50% of total dustfall when elevated dustfall readings occurred at these sites (stations 62035, 62036 and 62050). Road dust, and biological matter (eg. pollen, insect parts) were also sometimes present in significant amounts in dustfall, mainly during the summer. A comparison of average dustfall during recent years (Table 7) shows an encouraging trend of decline. The estimated 6% of total average dustfall occurring as saltcake (the lowest yet recorded) confirmed the decline in sodium found in vegetation.

In 1990, total suspended particulate matter (TSP) was typical of the value recorded in recent years. The annual average TSP at the monitoring site near the mill (station 62035) was 58 $\mu g/m^3$, which met the provincial objective. Sixteen of the 60 daily readings at this site exceeded the 24-hour objective. Highest levels occurred during calm conditions or with south to southwest wind, when the monitor was downwind of the mill. The annual average TSP at the Fort Frances cemetery (station 62032) was 28 $\mu g/m^3$, which is normal for this location and well within the Ontario objective. There were no exceedences of the daily objective at this site.

6.3 Odour Levels

The number of exceedences of the TRS guideline increased from 1989 to 1990 at the monitoring site (station 62030) near the Boise Cascade Canada mill but decreased at the site (station 62032) nearest Boise's U.S. mill (Table 8). Two other TRS monitoring sites (62047 on Eighth Street, 62051 at La Verendrye Hospital) completed their first full year of operation in 1990. During the year, there were 216 TRS guideline exceedences on Eighth Street, near the "lagoon" which receives effluent from the Boise Cascade Canada mill. At the hospital, there were 56 guideline exceedences.

Figure 7 displays TRS concentrations in 1990 for different wind directions at the four Fort Frances monitoring sites. The data show that the Boise Cascade Canada mill was the most significant TRS source during the year. However, the International Falls mill and the Eighth Street lagoon were also strong sources at times.

To reduce TRS emissions, a condensate stripper system is being commissioned at the Fort Frances mill. This project, delayed from 1990, will result in lower TRS discharges from both the mill and the secondary treatment "lagoon" on Eighth Street. Other steps to

improve air quality include the installation of a continuous stack monitor at the lime kiln, plus real-time acquisition of data from the Ministry's air quality stations. Later in 1991, Boise Cascade will carry out further emission tests to verify progress.

Data from the monitoring station near the Civic Centre (station 62030) was published daily as an Air Quality Index (AQI) starting November 15, 1989. During 1990, there were 850 hours of "moderate" air quality, and 511 hours of "poor" air quality. At other times, the AQI was "very good" or "good" at this location.

7.0 KENORA

For many years, the Ministry has monitored air quality near a sulphite pulp mill in Kenora. The current monitoring program includes dustfall measurements at four locations (Figure 8).

7.1 Particulate Matter

In 1990, only one of the four monitoring sites (station 61007, just north of the mill) experienced average dustfall slightly above the air quality objective. Only 3 of 47 monthly samples exceeded the objective. The recent installation of a new $5 million precipitator for the pulp mill's power boilers has evidently helped reduce fallout of particulate matter in the nearby residential area.

Average dustfall in Kenora has shown a clear trend of improvement over the past 17 years, despite much year-to-year fluctuation (Figure 9).

8.0 MARATHON

The Ministry currently maintains one air quality monitoring station in Marathon (Figure 10). A continuous analyzer at this station monitors odour levels near the kraft pulp mill operated by James River-Marathon, Ltd. The company also has dustfall jars at five sites to measure fallout of particulate matter near a storage area for wood chips.

8.1 Particulate Matter

The fallout of wood fines from wood-chip piles near the pulp mill ("wood storage area", Figure 10) has been studied by the company and by the Ministry.[17] Dustfall measurements for 1990 by the company indicated general compliance with dustfall objectives at sites off company property. A few elevated readings occurred during the early spring, but these were not caused by dust from wood-chip piles.

8.2 Odour Levels

Average annual TRS (Table 9) and the number of guideline exceedences decreased from 1989 to 1990. This improvement in air quality was attributed to better operating procedures at the mill.

9.0 RED LAKE

In response to concerns about lead emissions, the Ministry began a monitoring program in early 1988 near Accurassay Laboratories Limited in Red Lake. Accurassay performs fire assays of ore samples in support of gold mining and exploration work in the area. During sample analysis, about 0.4 grams of lead per sample are lost and assumed to be discharged to atmosphere.

9.1 Lead Levels

A snow sampling survey conducted in early March, 1988, showed that lead concentrations in snow off Accurassay property slightly exceeded the Ministry's contaminant guideline.[18]

Air quality data were collected with a high-volume sampler located on a residential property about 70 metres east of Accurassay. From February 9, 1988 to December 31, 1990, only 8 of 154 samples exceeded the maximum acceptable limit of 120 μ/m^3 for total suspended particulate matter.

Two samples (both in 1988) had lead levels above the maximum acceptable concentration of 5 μ/m^3. All the high concentrations of suspended particulate and lead occurred before August, 1989, when emission controls were installed.

To confirm that there are no further concerns about emissions from Accurassay, a snow sampling survey will be carried out when the company is operating normally. Air sampling near Accurassay was terminated at the end of 1990.

10.0 RED ROCK

The Ministry operates a small air quality monitoring network in the Town of Red Rock to measure dustfall and odours near a kraft pulp mill. The network comprises four dustfall jars at stations 63080 to 63083, and a continuous TRS analyzer at station 63084 (Figure 11).

10.1 Particulate Matter

In 1989, dustfall at all four of the monitoring sites off mill property met the annual air quality objective; only 4 of the 48 samples exceeded the monthly objective of 7 $g/m^2/30$ days.

The 11-year trend for Red Rock dustfall is shown in Figure 12. The graph shows the sharpest drop in average dustfall in 1983, just after a new recovery furnace was installed at the pulp mill. Because dustfall levels are now generally acceptable, dustfall measurement was discontinued in early 1991.

10.2 Odour Levels

There were 80 exceedences of the TRS guideline in 1990, up from 44 in 1989 (Table 10).

Some of the exceedences occurred during unscheduled shutdowns of the lime kiln. While such incidents may recur in future, the mill has upgraded its blow heat recovery system and is in the process of re-building its brown stock washers. Both these developments will reduce TRS emissions and improve air quality.

11.0 SCHREIBER

Concerns have been expressed about dust emissions from a transfer facility on CP Rail property. The facility receives ore concentrate from a base metal mine 20 km northwest of Schreiber.

11.1 Particulate Matter

The first Ministry studies showed that fallout of dust from the transhipment area resulted in significantly elevated copper and zinc in moss samples exposed off company property. Cadmium and iron were slightly above Ministry guidelines.[19,20] The latest surveys [21,22,23] revealed that airborne levels of cadmium, copper and zinc were acceptable up to early 1991. Moss exposure tests showed a sharp decline in metal levels from the summer of 1988 to

the summer of 1989, but an increase from 1989 to 1990. While a dust control program implemented by CP Rail in early 1989 has clearly provided some benefit, there was evidence of slippage in the application of the controls in 1990. Dust control was tightened up in early 1991.

12.0 TERRACE BAY

The Ministry's monitoring program in Terrace Bay is directed toward measurement of odour levels in the townsite and near a new secondary treatment system (lagoon) beside the Kimberly-Clark of Canada Limited kraft pulp mill (Figure 13).

12.1 Odour Levels

In the townsite, air quality improved from 1989 to 1990, as Table 11 shows. The number of TRS guideline exceedences (51) was the lowest for the past 5 years.

A large aerated stabilization basin (lagoon) receiving effluent from the pulp mill was brought into service in early September, 1989. In response to concerns about possible odours from this source, the Ministry installed a TRS monitor at station 63093 near the lagoon (Figure 13). In 1990, there were 204 exceedences of the TRS guideline at this site, down from 373 in 1989. Comparison of TRS before and after the lagoon became operational, showed no major change in the townsite (station 63090), but a sharp decline near the lagoon (station 63093). Figures 13a and 13b summarize the results. This experience indicates that the lagoon, to date, has not been a major odour source. The strongest TRS source appears to be the spill pond; the mill is a secondary source, and the lagoon a minor source. Moss exposure surveys in 1989 and 1990 (report in preparation) provided further evidence that the lagoon was not a significant air pollution source.

13.0 THUNDER BAY

In 1990, the Ministry operated an 8-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 14. One station (63200) records all continuously measured pollutants. These include sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, particulate matter (soiling index) and total reduced sulphur. Three of the Ministry's Thunder Bay stations (63005, 63022 and 63200) are part of Environment Canada's National Air Pollution Surveillance network. Ontario Hydro also operates five sulphur dioxide monitors in the city. The following sections summarize 1990 air quality data from Thunder Bay.

13.1 Particulate Matter

13.1.1 Dustfall

In January, 1990, the Thunder Bay dustfall network was reduced from 10 sites to 2. At the sites deleted, average dustfall had been consistently low for several years.

For the two sites where dustfall measurements continued in 1990, a data summary appears in Table 12. There was one exceedence of the monthly objective at Can-Car (station 63046) and four at Totem Trailer Court (station 63047). The annual objective for dustfall was met at Can-Car, but not at the Trailer Court. When dustfall was elevated at the Trailer Court, wood fines and wood char, emitted by Canadian Pacific Forest Products Ltd., accounted for up to 65% of total dustfall.

13.1.2 Suspended Particulate Matter (TSP) and Soiling Index

Total suspended particulate matter was very satisfactory throughout Thunder Bay in 1990 (Table 13). All but one of the 348 samples from six monitoring sites were below the 24-hour maximum acceptable limit of 120 $\mu g/m^3$. The annual objective was met at all locations.

Samples from the two city-centre stations (stations 63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, which are influenced by long-range transport, varied considerably.

TSP in Thunder Bay now substantially complies with air quality objectives and a large data base has been established. For these reasons, and the need to direct some of our monitoring effort to other concerns (eg. inhalable particulates and organics), the TSP network was reduced from six sites to four at the end of 1990.

At station 63200, soiling index met the daily and annual air quality objectives.

13.1.2 Inhalable Particulate Matter (IPM)

Sampling for inhalable particulate matter (IPM) began at station 63200 (Walsh and James Street) in July, 1989. In 1990, IPM ranged from 6 to 62 $\mu g/m^3$, with an arithmetic mean of 19 $\mu g/m^3$. At present, Ontario is developing an objective for IPM. In the United States, standards range from 50 to 150 $\mu g/m^3$ for single samples, and from 30 to 50 $\mu g/m^3$ for annual averages.

13.2 Gaseous Pollutants

13.2.1 Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Ozone (O_3)

Throughout the year, carbon monoxide was well below the maximum acceptable limit for 1-hour and 8-hour averages at station 63200. Nitrogen dioxide met the 1-hour and 24-hour objectives. Ozone met the provincial 1-hour objective of 0.08 ppm at all times in Thunder Bay. Ozone, a long-range transport pollutant, is not currently considered a problem in northwestern Ontario. Summary figures for carbon monoxide, nitrogen dioxide and ozone are in Table 14.

13.2.2 Sulphur Dioxide (SO_2)

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt lignite-fired generating station and four pulp and paper mills. Collectively, these sources are relatively small; total SO_2 emissions in Thunder Bay are less than 100 metric tons per day. The network of seven SO_2 monitors (five belonging to Ontario Hydro and one owned by the Ministry) showed full compliance for all SO_2 air quality objectives in 1990 (Table 15).

13.2.3 Total Reduced Sulphur (TRS)

At the Ministry's Montreal Street monitoring site (station 63046), there were 16 exceedences of the TRS guideline in 1990 (Table 16). There were no exceedances of the guideline at the Thunder Bay Air Quality Index station (James and Walsh).

13.2.4 Organic Compounds

In July, 1990, a sampler for PAH (polynuclear aromatic hydrocarbon) compounds was installed in Thunder Bay north to obtain data on general urban PAH levels. The other purpose of this monitor is to assess PAH concentrations downwind of Northern Wood Preservers Inc. Northern Wood uses creosote and, occasionally, pentachlorophenol wood preservatives. Both these substances contain PAH compounds, some of which are suspected causes of cancer. Because Northern Wood temporarily ceased production in late 1990, no conclusive data are available yet.

To measure urban concentrations of VOCs (volatile organic compounds), a sampler was installed in the Thunder Bay Air Quality Index station in October, 1990. This monitor will determine the levels of organic compounds such as benzene, xylene, and toluene, which have known toxic health effects. Although the available results are very limited, VOC levels have so far been found to be low.

13.3 Air Quality Index (AQI)

An hourly Air Quality Index was determined for the six pollutants continuously monitored at station 63200 (Walsh and James Street), Thunder Bay. During 1990, the AQI was very good or good for all but 17 hours when it deteriorated to the moderate category. The pollutant responsible for 1 hour of moderate AQI was TRS; all the other moderate readings were due to suspended particles. One incident of elevated suspended particles, on November 30, caused four consecutive hours of moderate air quality and noticeably reduced visibility.[24] The cause for the November 30 episode was an accumulation of vehicle emissions trapped under a layer of warm air near the ground.

13.4 Special Studies

13.4.1 Thunder Bay Terminals Limited

A report on 1990 monitoring near Thunder Bay Terminals Limited[23] showed that provincial air quality objectives were substantially met. Western coal and potash are the main products handled at Thunder Bay Terminals. There has been no increase in dust levels at off-property monitoring sites since shipments began in 1978. Snow sampling in early 1991 showed that, compared to 1990, there was a sharp decline in fallout of coal particles on the ice-covered harbour east-southeast of the terminal. A dust control program implemented by the company is credited with this improvement.[25]

REPORTS ISSUED IN 1990

The following list includes "green cover" reports and technical memoranda released during 1989. For each document, a brief summary is included. Items already listed under "References" for this report (see pages 30-36) are excluded.

"Green Cover" Reports

1. Air quality, northwestern Ontario, 1988.

   Results of the Ministry's air quality assessment program for 1988 in northwestern Ontario were presented.

Technical Memoranda:

1. Vegetation assessment surveys near the Ministry of Transportation's Longbow Lake patrol yard, 1988-89.

Salt losses from a patrol year injured nearby vegetation. Damage was significant in 1988. Improved salt-handling procedures reduced the extent and severity of damage in 1989.

2. Air quality assessment, Thunder Bay Terminals Ltd., Thunder Bay, 1989.

   Provincial air quality objectives were met, though some fallout from windblown coal dust was found nearby on ice-covered Lake Superior. Abatement action was recommended.

3. Ministry of the Environment air quality telemetry system: users guide for abatement staff (revised edition).

   Procedures were outlined for abatement staff to obtain air quality data reports.

4. Snow sampling survey near Canadian Pacific Forest Products Limited, Thunder Bay, February, 1989.

   Contaminant guidelines for snow were occasionally exceeded off company property. Levels of fallout, however, met Ministry regulations.

5. Snow sampling survey in the vicinity of Minnova Inc., Schreiber, 1988.

   Levels of cadmium, copper, iron and zinc were elevated on company property.

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2. Ontario Ministry of the Environment. 1979. Method of high volume sampling and determination of total suspended particulate matter in ambient air. Report AMP-101. Air Resources Branch.

3. Ontario Ministry of the Environment. 1981. Method for the sampling and determination of carbon monoxide in ambient air by non-dispersive infrared spectrometry. Report AMP-123. Air Resources Branch.

4. Ontario Ministry of the Environment. 1981. Method for continuous sampling and determination of nitrogen dioxide and nitric oxide in ambient air by chemiluminescence. Report AMP-121. Air Resources Branch.

5. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of ozone in ambient air by chemiluminescence. Report AMP-120. Air Resources Branch.

6. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of sulphur dioxide in ambient air by fluorescence. Report AMP-118. Air Resources Branch.

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10. Ontario Ministry of the Environment. 1981. Outlines of analytical methods. Laboratory Services Branch.

11. Ontario Ministry of the Environment. 1979. Method for sampling and determination of fluoride in vegetation. Report AMP-111. Air Resources Branch.

12. Racette, D. J. and H. D. Griffin. 1986. Pre-operational terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1981 to 1985. Ontario Ministry of the Environment.

13. Racette, D. J. and H. D. Griffin. 1989. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1986. Ontario Ministry of the Environment.

14. Racette, D. J. and H. D. Griffin. 1990. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1987-89. Ontario Ministry of the Environment (in preparation).

15. Racette, D. J. and H. D. Griffin. 1990. Air quality studies near coal storage and ash disposal areas, Ontario Hydro generating station, Atikokan, 1989. Ontario Ministry of the Environment.

16. Griffin, H.D. 1990. Interim results of air quality monitoring near Dickenson Mines Limited, Balmertown, 1989-90. Ontario Ministry of the Environment.

17. Racette, D. J. and H. D. Griffin. 1987. Dustfall and snow sampling in the vicinity of James River-Marathon Limited, Marathon, 1985-86. Ontario Ministry of the Environment.

18. Racette, D. J. and H. D. Griffin. 1989. Snow sampling survey in the vicinity of two mineral assay laboratories in the Red Lake area, 1988. Ontario Ministry of the Environment.

19. Racette, D. J. and H. D. Griffin. 1989. Moss bag exposure survey in the vicinity of the CPR concentrate transhipment facility, Schreiber, 1987-88. Ontario Ministry of the Environment.

20. Racette, D. J. and H. D. Griffin. 1989. Snow sampling survey near the CP Rail ore concentrate transhipment facility, Schreiber, 1989. Ontario Ministry of the Environment.

21. Racette, D. J. and H. D. Griffin. 1989. Air quality studies near an ore concentrate transhipment site, Schreiber, 1989. Ontario Ministry of the Environment.

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23. Racette, D. J. and H. D. Griffin. 1991. Air quality studies near an ore concentrate tran-shipment site, Schreiber, 1990-91. Ontario Ministry of the Environment.

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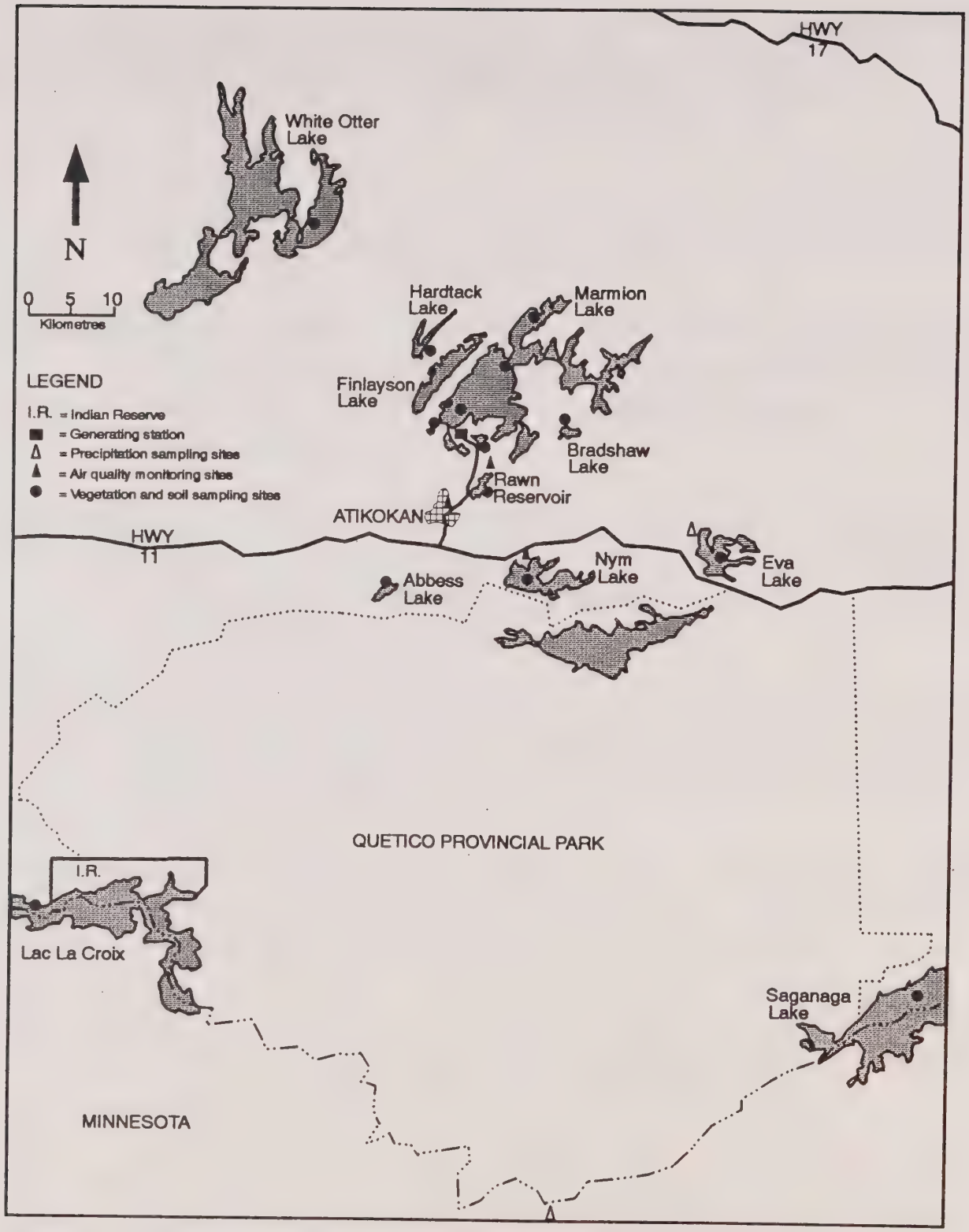

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan, 1990.

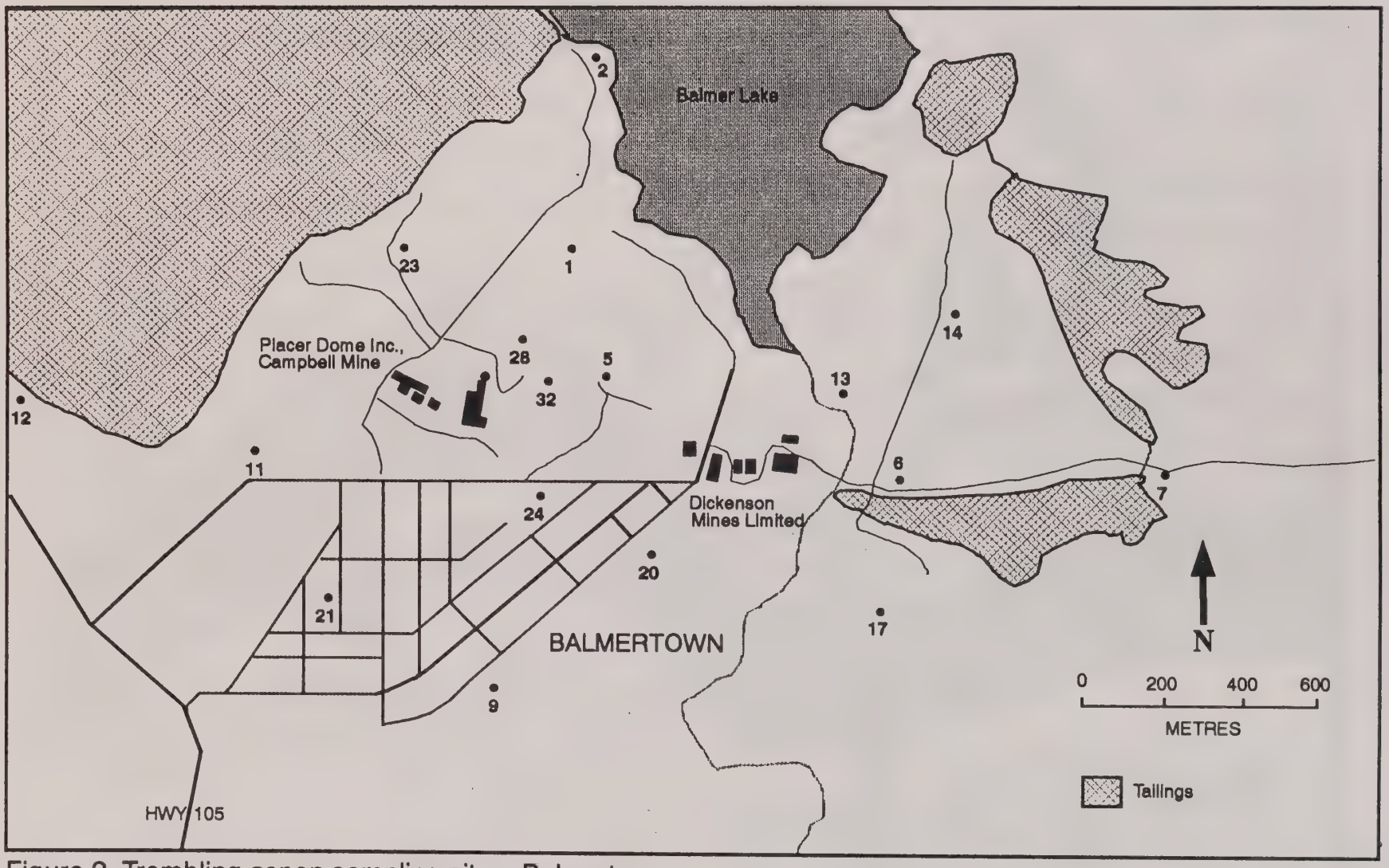

Figure 2. Trembling aspen sampling sites, Balmertown.

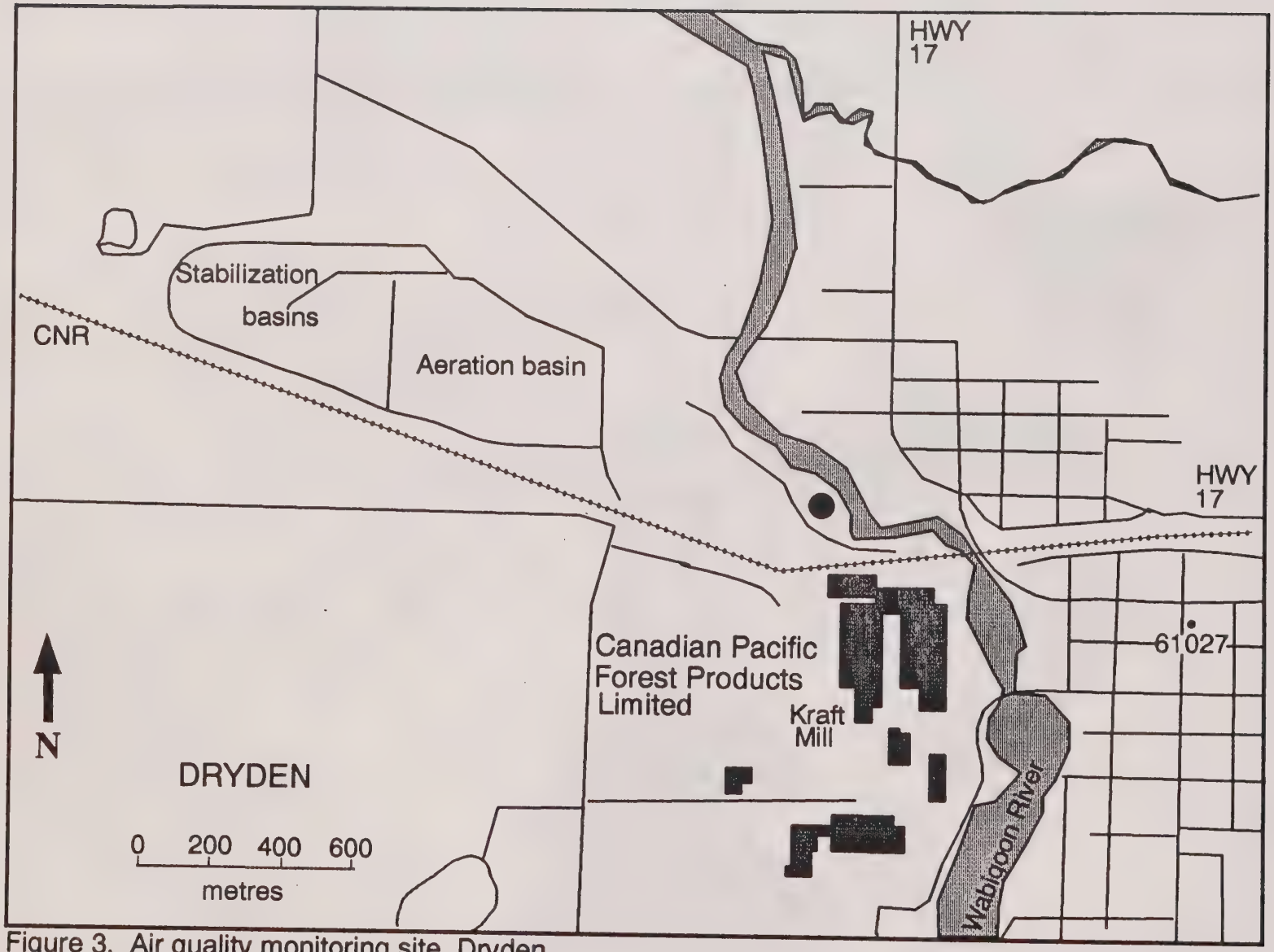

Figure 3. Air quality monitoring site, Dryden.

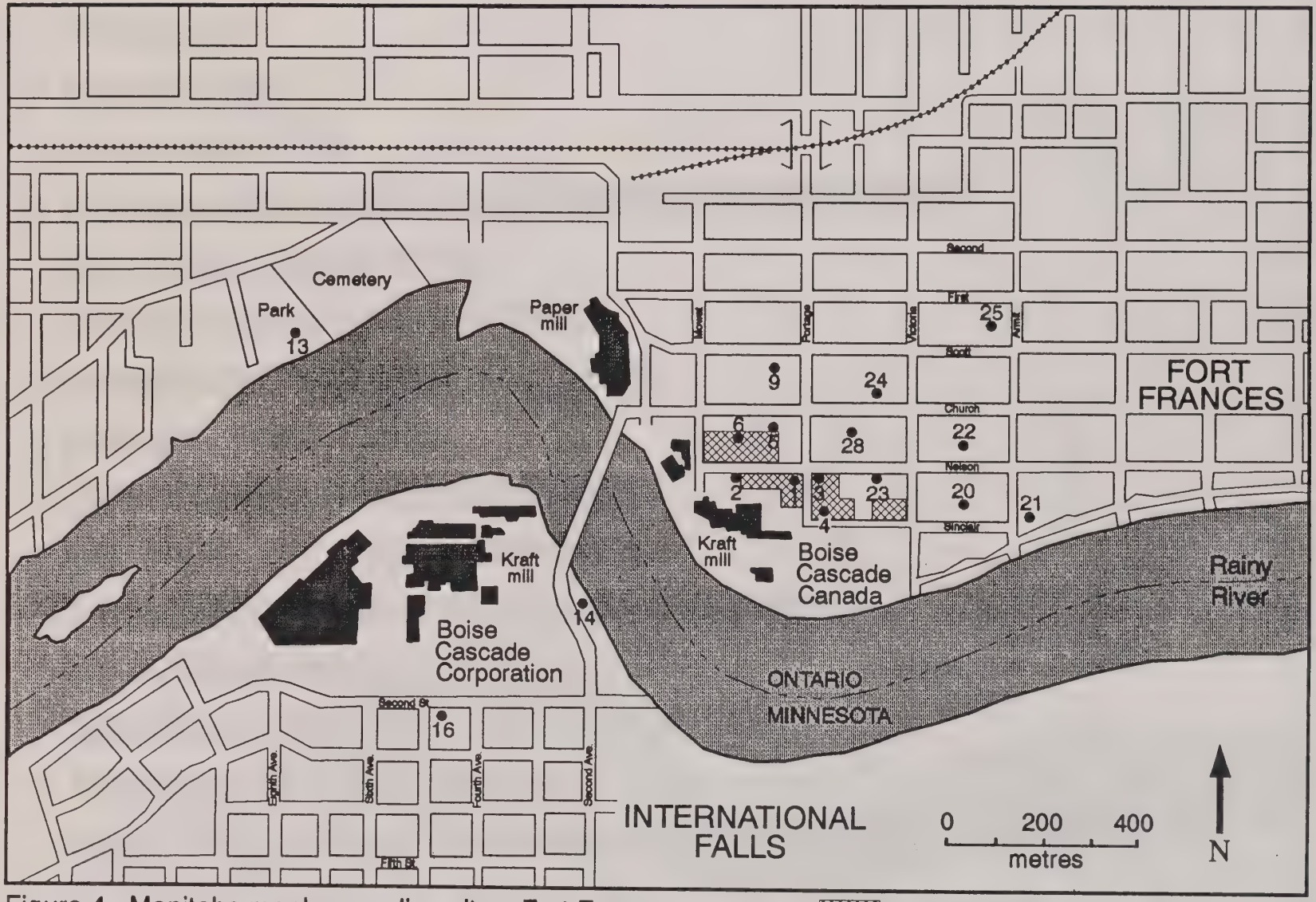

Figure 4. Manitoba maple sampling sites, Fort Frances. Buffer zone

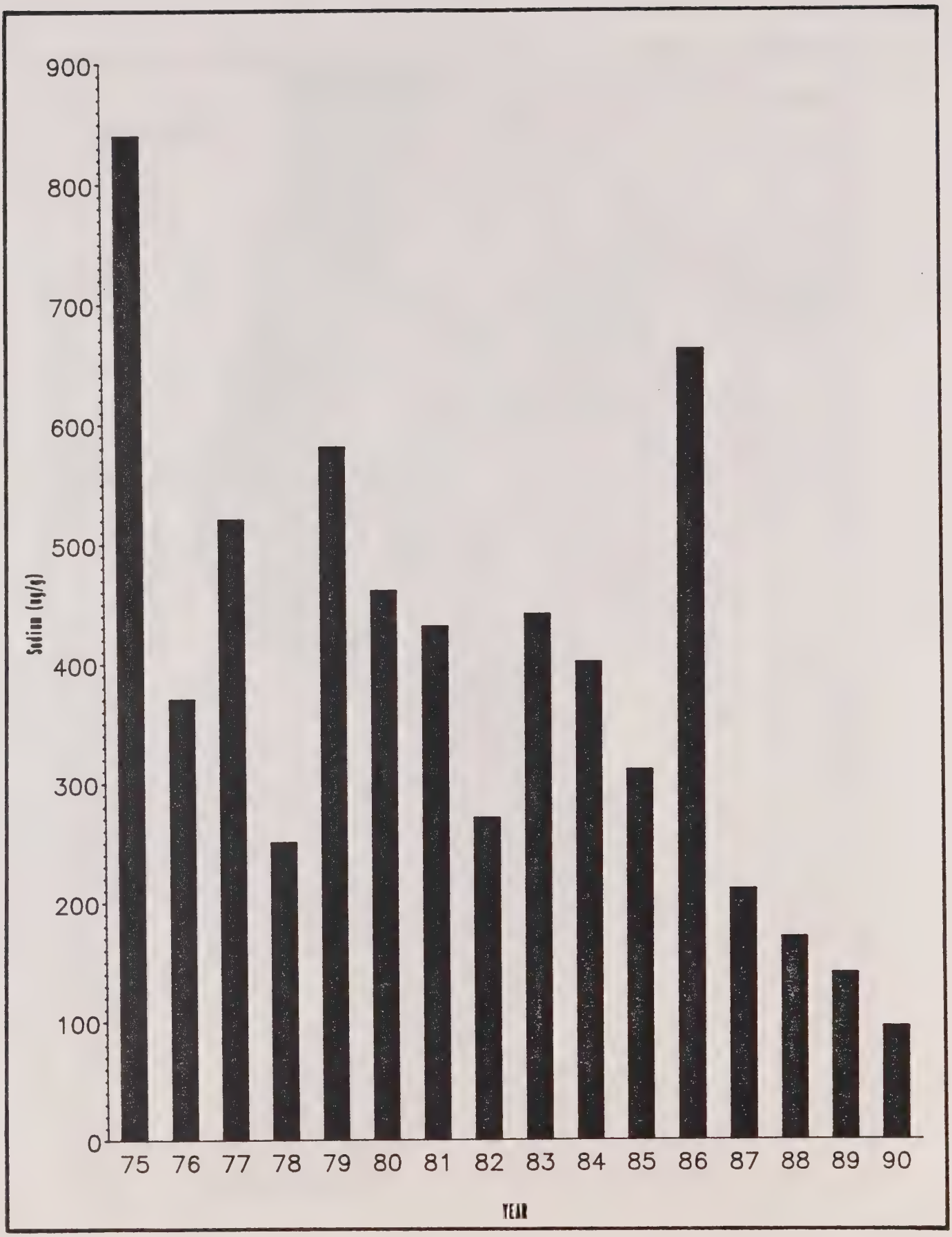

Figure 5. Average sodium (ug/g, dry weight) in Manitoba maple (Acer negundo) foliage, Fort Frances–International Falls, 1975–1990.

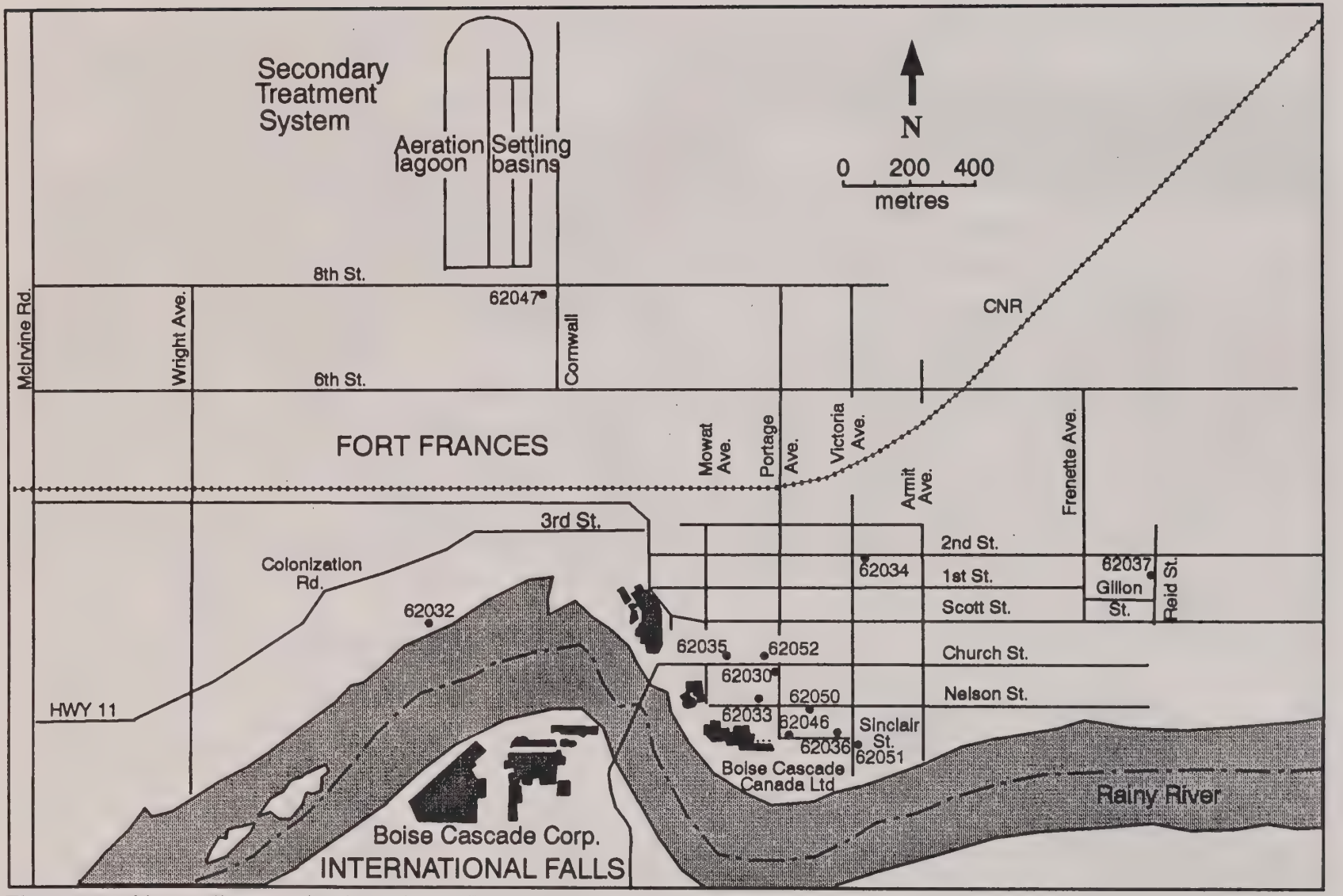

Figure 6. Air quality monitoring sites, Fort Frances.

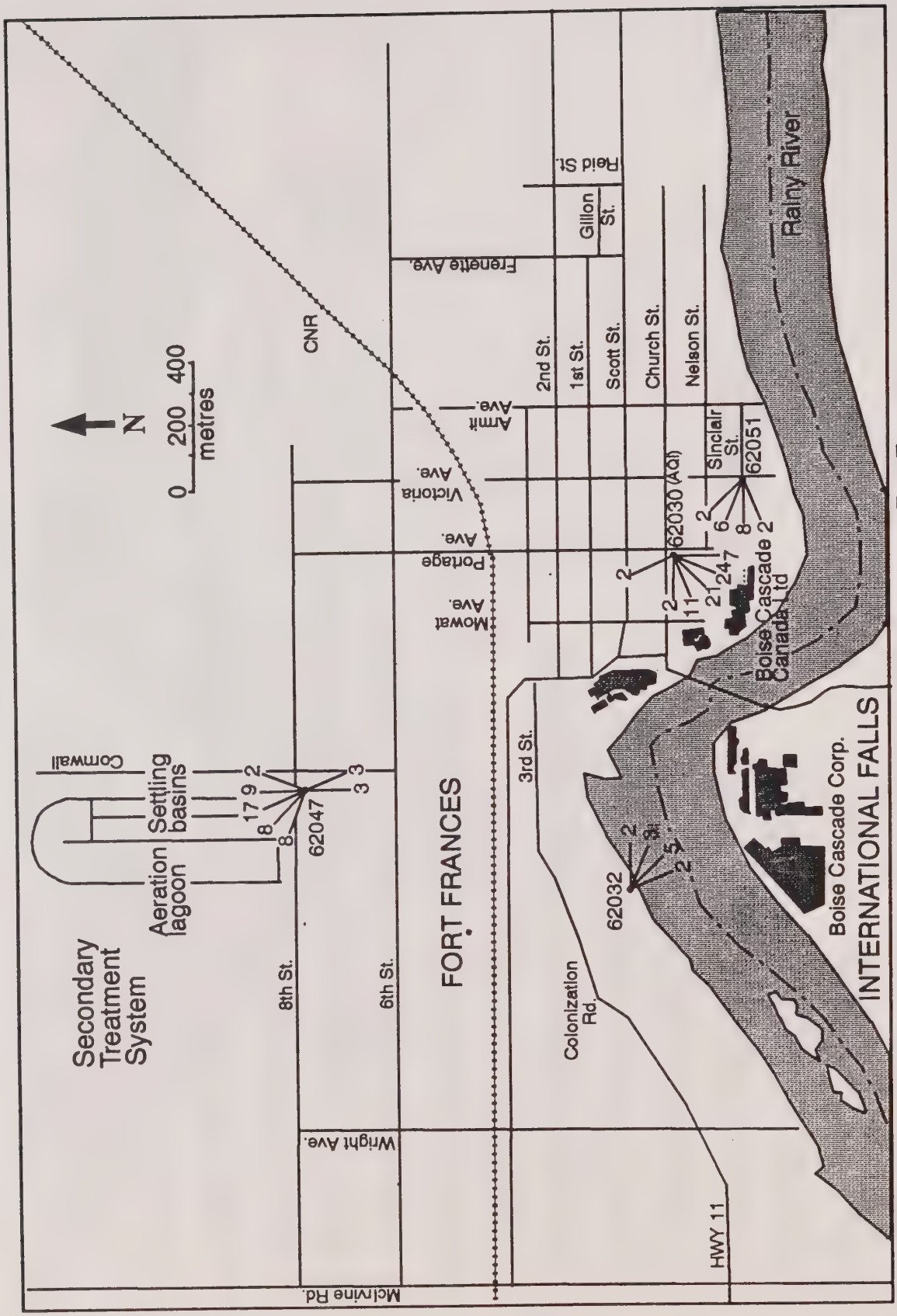

Figure 7. Average 1990 TRS levels (ppb) for different wind directions, Fort Frances.

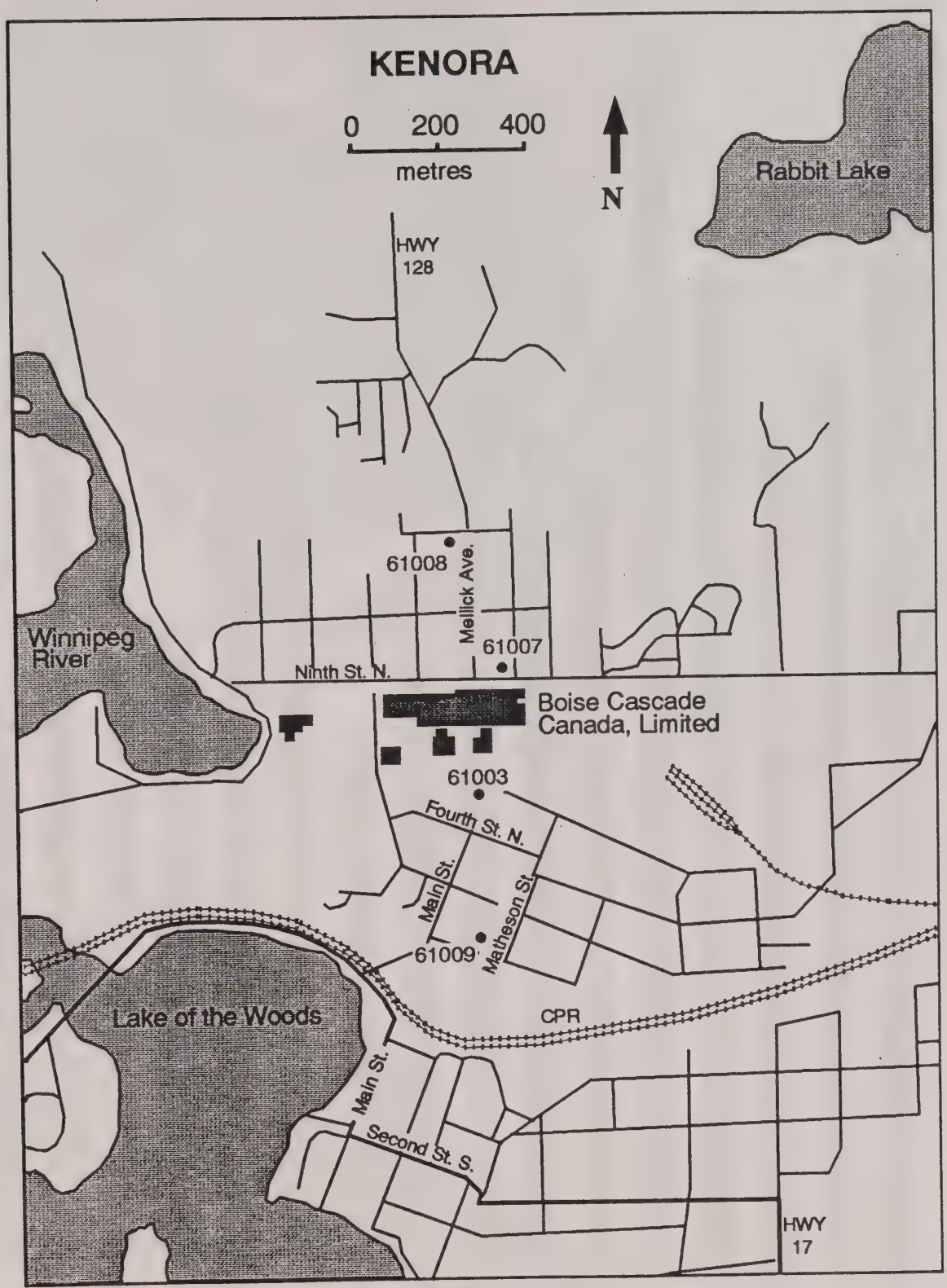

Figure 8. Air quality monitoring sites. Kenora.

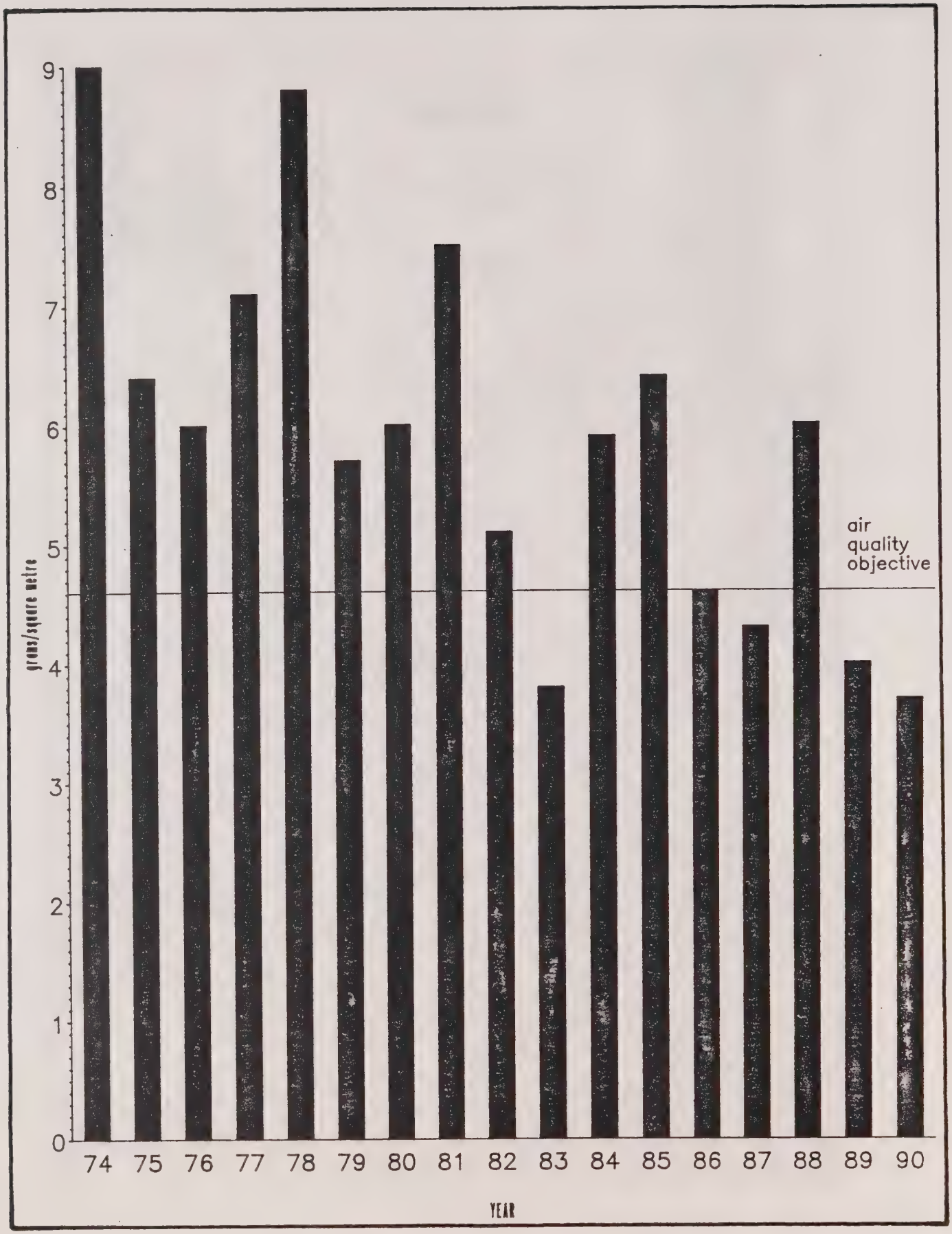

Figure 9. Dustfall, Kenora, 1974–1990 (average of 3 stations, 1974–80, and 4 stations, 1981–90).

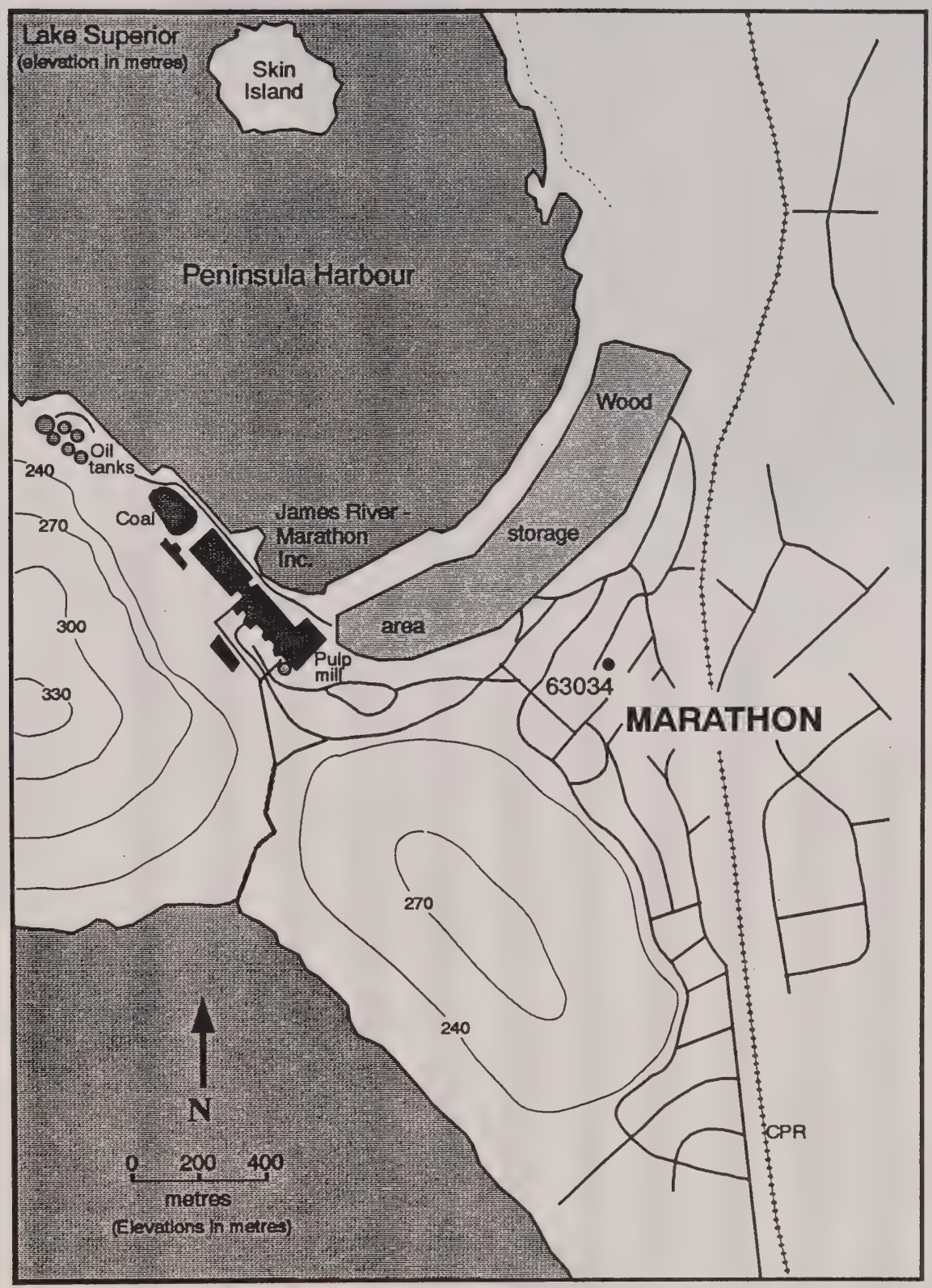

Figure 10. Air quality monitoring site, Marathon.

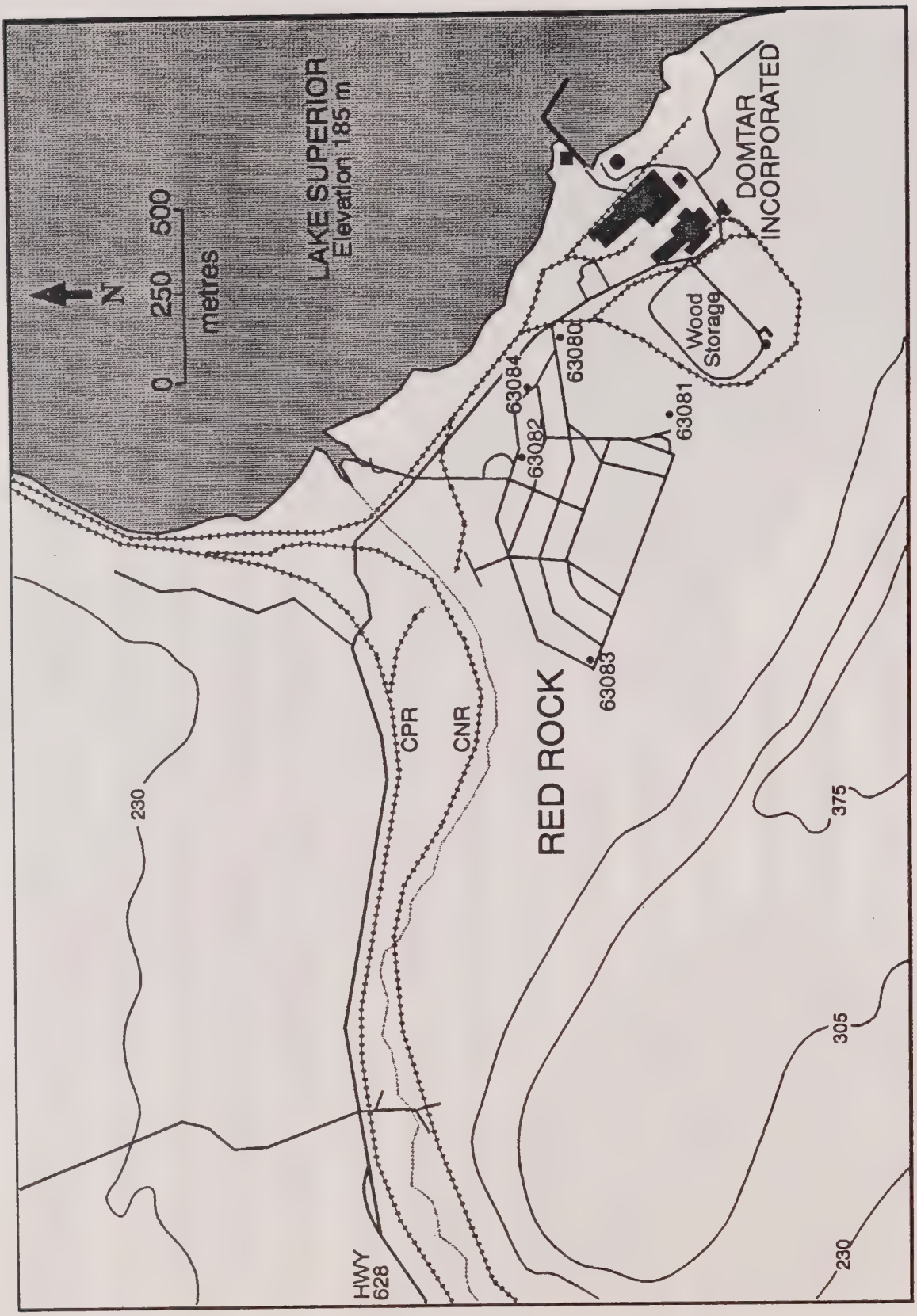

Figure 11. Air quality monitoring sites, Red Rock.

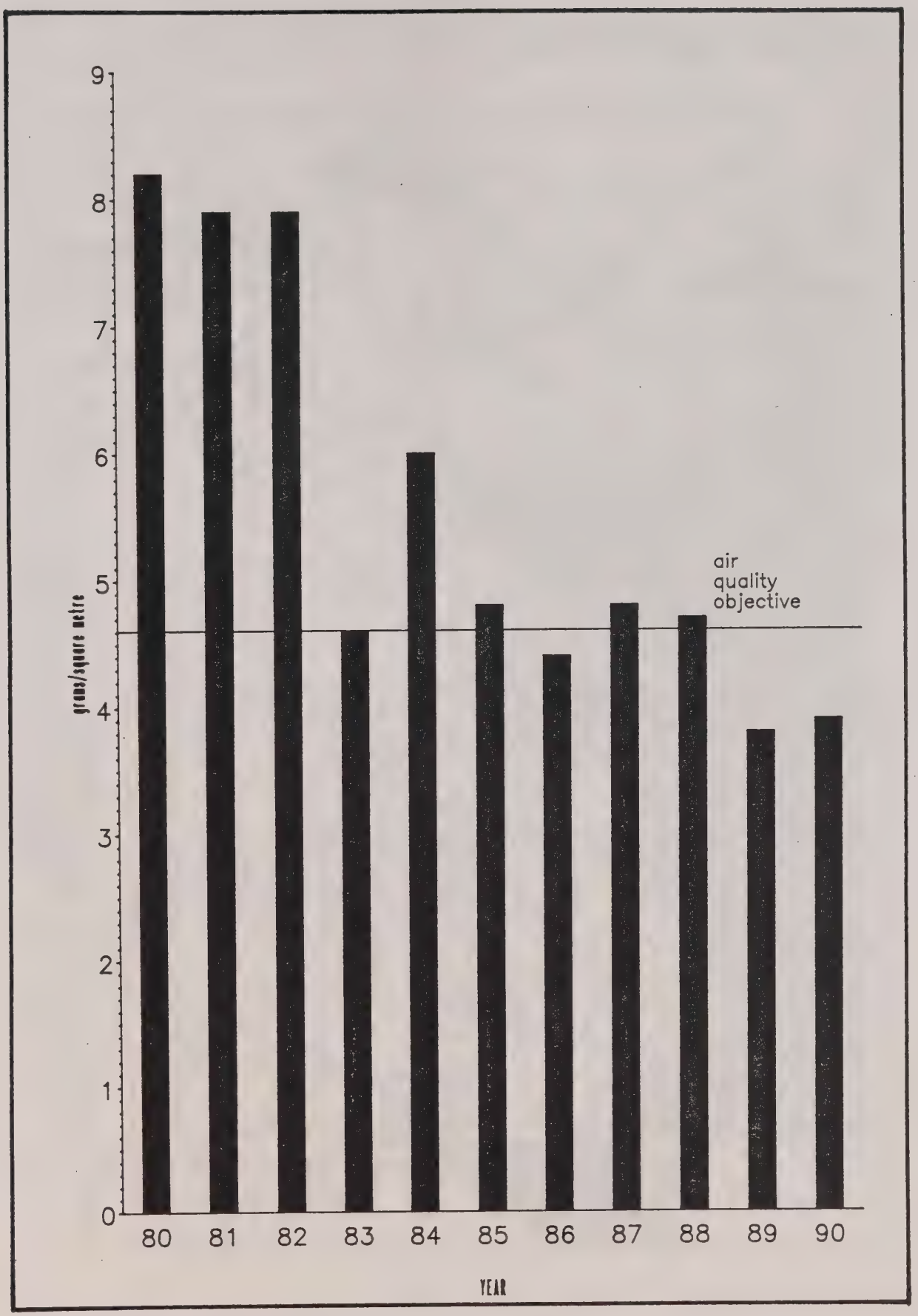

Figure 12. Dustfall, Red Rock, 1980–1990 (average of four monitoring sites).

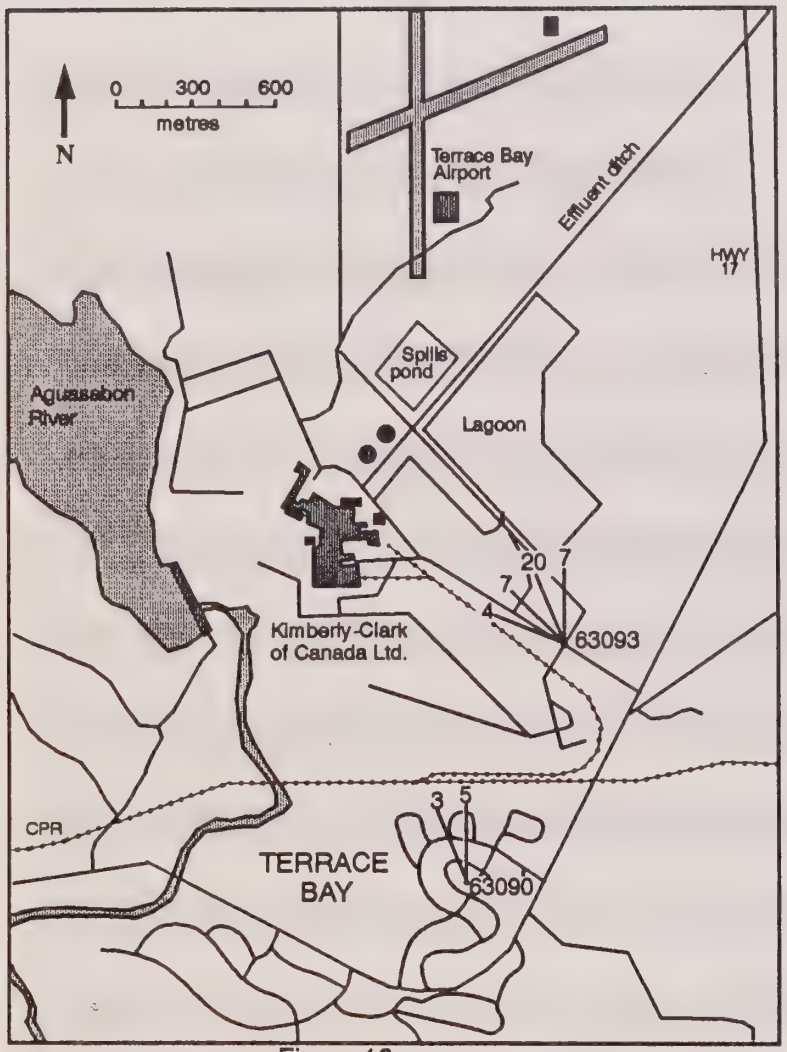

Figure 13a.

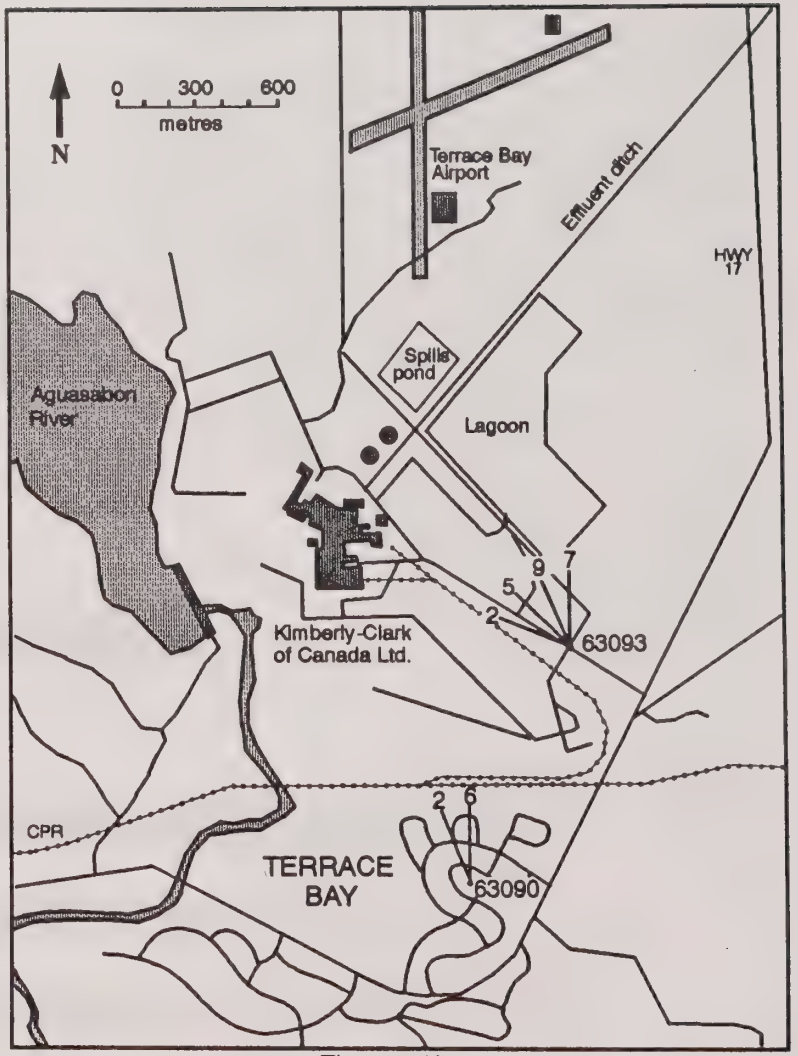

Figure 13b.

Figure 13. Average TRS levels (ppb) for different wind directions, Terrace Bay.
a. Before lagoon began operation (Feb. - Aug., 1989).
b. After lagoon began operation (Jan. - Dec., 1990).

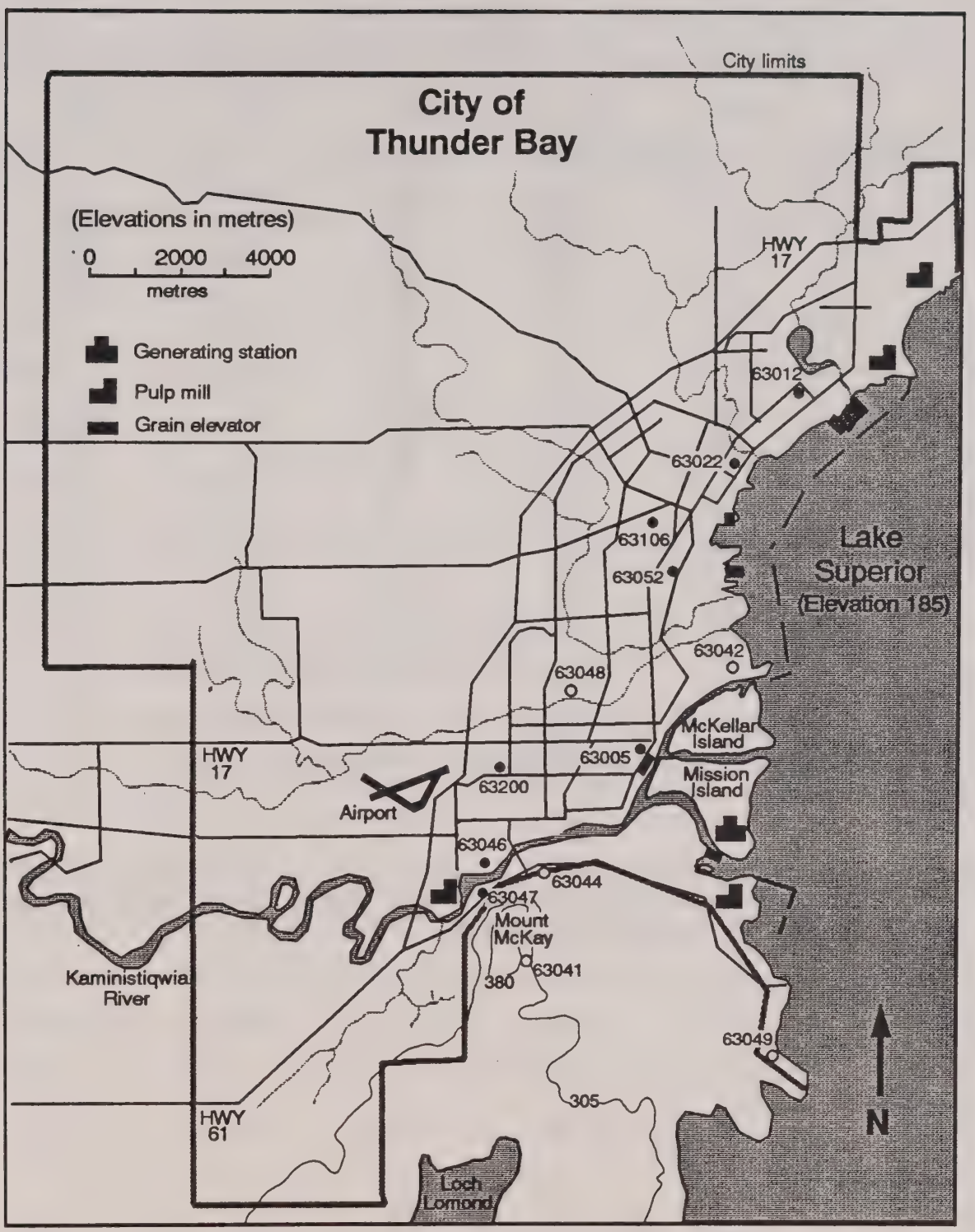

Figure 14. Air quality monitoring sites, Thunder Bay, 1990.
(o Ontario Hydro sites)

TABLE 1. Arsenic content (µg/g, dry weight) of trembling aspen foliage, Balmertown, 1986-90.

Site[a]	1986	1987	1988	1989	1990
1	6	19	6	7	9
2	8	52	9	8	15
5	23	24	13	10	12
6	28	15	24	9	33
7	6	4	3	2	3
9[c]	6	7	5	4	4
11	4	11	7	9	22
12[c]	1	5	3	2	4
13	160	140	230	36	440
14	75	20	42	6	29
17	13	11	17	10	5
20[c]	2	11	7	5	4
21[c]	2	6	4	6	4
23	15	<1	7	9	48
24[c]	5	18	5	7	12
28	180	150	33	36	38
32	32	61	36	17	16
Controls	<1	<1	<1	<1	<1

[a]Shown in Figure 2.
[b]Values above guideline (2 µg/g) are underlined.
[c]Sites in townsite area.

TABLE 2. Average arsenic content (µg/g, dry weight) of foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1986-90.

Site[a]	1986	1987	1988	1989	1990
Dickenson & Mine Rd.	26	18	18	18	13
Balmertown public school	4	14	8	8	8
Fifth St. & Mine Rd.	12	10	7	12	20
Control (Red Lake)	<1	<1	<1	<1	1

TABLE 3. Summary of sulphur dioxide data, Balmertown, 1986-90.

Year	Days of data	Annual ave. (ppm)	Annual exceedences Hours	Annual exceedences Days	Growing season exceedences Hours	Growing season exceedences Days
1986	355	0.008	79	2	28	1
1987	332	0.010	87	7	23	1
1988	353	0.008	53	2	19	0
1989	334	0.010	86	3	34	2
1990	364	0.007	63	5	34	2

TABLE 4. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1986-90.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1986	352	1.0	77	12
1987	346	0.5	26	0
1988	323	0.4	45	1
1989	362	0.4	20	0
1990	356	0.4	51	3

TABLE 5. Average sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980 and 1987-1990.

Site[a]	1980	1987	1988	1989	1990
1[b]	1800[d]	390	410	250	260
2[b]	1400	290	200	180	300
3[b]	1200	230	90	110	130
4[b]	620	110	110	170	120
5	260	100	120	120	100
6	390	300	240	250	150
9	150	240	130	110	78
13	83	140	160	60	61
14[c]	53	180	280	130	45
16[c]	73	150	440	130	51
18	120	220	85	130	44
20	250	370	70	90	44
21	250	200	75	90	39
22	140	430	190	95	60
23	280	140	75	95	55
24	210	65	95	210	62
25	410	160	90	120	58
28		85	130	230	58
Average, all sites	460	210	170	140	95
Controls	100	38	95	68	19

[a]See Figure 4 for site locations.
[b]Sites on Boise Cascade Canada property.
[c]U.S. Sites.
[d]Values above contaminant guideline (350 μg/g) are underlined.

TABLE 6. Average annual dustfall ($g/m^2/30$ d), Fort Frances, 1990.

Monitoring sites[a]	Total dustfall	Insoluble dustfall
62032	3.1	1.8
62033[b]	9.6	6.5[c]
62034	4.4	2.3
62035	6.9	5.1
62036	6.7	4.3
62037	2.1	1.1
62046[b]	7.3	4.6
62050	5.3	2.9
Average, sites off mill property	4.8	2.9
% of total dustfall, off-property sites		60

[a] See Figure 6.
[b] Sites on company property.
[c] Values above the maximum acceptable limit ($4.6 g/m^2/30$ d) are underlined.

TABLE 7. Average annual dustfall ($g/m^2/30$ d) at six Fort Frances monitoring sites off mill property, 1986-90.[a] Percentages of total dustfall are shown in parentheses.

Parameter	1986	1987	1988	1989	1990
Total dustfall	7.1	5.9	6.1	5.1	4.8
Insoluble dustfall	3.8(54)	3.1(52)	3.6(59)	3.0(59)	2.9(60)
Saltcake in dustfall	1.4(20)	1.1(19)	0.9(15)	NA[b]	0.3(6)

[a] Stations 62030/35, 62032, 62034, 62036, 62037, and 62050.
[b] Not available for 1989.

TABLE 8. Summary of total reduced sulphur concentration (ppb) at stations 62030, 62052 and 62032, Fort Frances, 1976-1989.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 62030/62052		
1976[a]	309	12.8	458	916
1977[a]	294	15.4	480	969
1978[a]	304	16.1	540	1035
1979[a]	344	10.2	353	911
1980[a]	352	9.3	499	872
1981[a]	277	12.0	279	806
1982[a]	320	8.8	543	685
1983[b]	336	4.9	254	418
1984[b]	332	2.8	98	135
1985[b]	363	2.0	191	87
1986[a,b]	335	3.9	226	300
1987[a]	359	5.5	278	431
1988[a,b]	359	5.9	268	552
1989[a,b]	365	5.0	126	414
1990[a]	360	5.5	159	493
		Station 62032		
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
1984	314	1.9	74	38
1985	363	1.1	61	28
1986	325	1.2	133	37
1987	345	1.8	215	61
1988	363	1.7	160	84
1989	331	1.4	262	61
1990	365	1.2	85	43

[a]Station 62030
[b]Station 62052

TABLE 9. Summary of TRS concentration (ppb) at station 63034, Marathon, 1986-90.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1986	316	2.1	131	115
1987	331	2.0	150	93
1988	327	2.2	67	109
1989	365	1.5	175	54
1990	351	1.1	101	21

TABLE 10. Summary of TRS concentrations (ppb) at station 63084, Red Rock, 1986-90.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1986	317	1.9	80	87
1987	337	3.1	216	203
1988	350	2.8	201	173
1989	296	1.4	77	44
1990	344	1.6	83	80

TABLE 11. Summary of TRS concentrations (ppb) at stations 63090 and 63093, Terrace Bay, 1986-90.

Years	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 63090		
1986	350	1.5	155	72
1987	316	2.4	159	121
1988	332	2.2	129	111
1989	342	1.4	95	64
1990	365	1.3	65	51
		Station 63093		
1989	344	4.4	180	373
1990	351	2.7	381	204

TABLE 12. Total dustfall ($g/m^2/30$ d), Thunder Bay, 1990.

Station[a]	Location	Monthly Min	Monthly Max	Annual average
63046	Montreal Street	0.6	10.2[b]	3.3
63047	Totem Trailer Court	<0.8	19.4	6.7

[a]See Figure 14.
[b]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 13. Total suspended particulate matter ($\mu g/m^3$), Thunder Bay, 1990.

Station[a]	Number of samples	Annual geometric mean	Number of samples above 120 $\mu g/m^3$	Maximum 24-hour value
63005	56	32	0	93
63012	57	29	0	72
63022	59	28	0	106
63046	59	43	1	141[b]
63052	59	38	0	113
63200	58	32	0	81

[a]See Figure 14.
[b]Values exceeding the maximum acceptable limit of 120 $\mu g/m^3$ (24-hour average) or 60 $\mu g/m^3$ (annual geometric mean) are underlined.

TABLE 14. Summary of carbon monoxide, nitrogen dioxide and ozone concentrations (ppm), station 63200, Thunder Bay, and ozone at Hawkeye Lake, 1990.

	Maximum 1-hour average	Maximum 8 hour average	Maximum 24-hour average
Carbon monoxide	15.0	7.9	
Nitrogen dioxide	0.08		0.03
Ozone, Thunder Bay	0.062		
Ozone, Hawkeye Lake[a]	0.074		

[a]40 km north-northwest of Thunder Bay.

TABLE 15. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1990.

Station[a]	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63200	615 S. James Street	<0.001	0.03	0.01
63041[b]	Mt. McKay		0.19	0.03
63042[b]	East End		0.08	<0.01
63044[b]	James St./Kam River		0.06	<0.01
63048[b]	Ford Street		0.08	<0.01
63049[b]	Chippewa Park		0.03	<0.01

[a]See Figure 14 for station locations.
[b]Ontario Hydro. 1990-91. Environmental Quality Compliance Reports, 1989. Central Production Services, Environmental Protection Department.

TABLE 16. Summary of total reduced sulphur concentrations (ppb), station 63046[a], Thunder Bay, 1986-90.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1986	337	1.0	55	4
1987	329	0.8	52	12
1988	361	1.0	36	5
1989	343	1.0	51	2
1990	354	1.0	40	16

[a]See Figure 14 for station location.